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Subjective Assessment of the Impact of Hearing Protectors on MTC Highway Equipment Operators

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EXECUTIVE SUMMARY

Excessive noise levels in the work place can threaten the health and well-being of employees. The MTC Occupational Health and Safety Office is concerned about the exposure of highway equipment operators to the noise of machinery and traffic. As a result the Human and Social Systems Section (now the Ergonomics Research Office) was asked to study the impact of wearing personal hearing protectors on the equipment operators' safety, their ability to communicate, and their comfort. Previous studies suggested the factors that should be considered when examining the impact of hearing protectors are how they affect the intelligibility of speech and the perception of warning sounds.

As a first step to the study, typical operator duties were analyzed and on-site samples of noise levels were collected. In order to assess the impact of hearing protectors and to study their acceptance by operators, on-the-job trial use of protectors was implemented. Two trial periods were used because operator duties differ between the winter and summer seasons. The summer trial period ran from October 1 to November 30, 1980, and the winter trial period ran from February 15 to March 15, 1981.

In the summer months highway equipment operators work in different types of crews, based on the types of operations that are performed. Certain crew types were chosen for participation in the study based on the number of operators assigned to that type throughout the province. Two crews of each type were then selected. For the summer trial session, the crew types included:

- three kinds of patrol crews: expressway, King's Highways and secondary highways crews;
- electrical crews;
- zone paint crews and
- forestry crews.

During the winter months operator duties consist, primarily, of snow removal and related activities, so crews were selected based on the type of area they work in. For the winter trial session, pairs of crews who patrol the following types of areas were selected: multi-lane highway with heavy usage; four-lane divided highway in a heavy snow area; and two-lane undivided highway.

After the pairs of crews were selected, one of each type was assigned to either the experimental or control group. Operators in crews assigned to the experimental group were given hearing protectors and were asked to wear them for the duration of the trial period when around loud noise. Operators in the control group were asked to pay particular attention to the noise around them. The wearing of hearing protectors was not compulsory for operators in the experimental group and a small number did not wear protection at all during the trial period. Also, some operators in the control group already wore hearing protectors and they were not asked to reduce their wearing time. In general, however, the experimental group wore hearing protectors at some time during the trial period and the control group did not wear protectors.

Data, to assess the impact of hearing protectors, were collected from questionnaires and group discussions. Pre-questionnaires were distributed to each operator before each trial period. These questionnaires requested information on demographics (e.g., age and job type), current hearing problems, exposure to noise and difficulties resulting from noise, and difficulties expected to result from the use of hearing protectors. Post-questionnaires, which closely paralleled the pre-questionnaires, were distributed after the trial session. In addition to the questions in the pre-questionnaire, the post-questionnaires asked the operators to report the frequency of their use of protectors and to give reasons for not using them. Operator comments about the use of protectors were also gathered in a group discussion which took place with each crew after the trial use period was complete.

The on-site sampling of noise revealed a wide range of noise level readings on both sides of the critical value of 90 dB. This emphasizes the variability of the work environment.

The questionnaires and group discussions revealed a high level of co-operation by the operators in the use of hearing protectors. The results for the summer trial period were favourable to the implementation of some type of hearing protection program. Operators acknowledged that they were frequently exposed to loud noises, that noise causes some difficulties and that they feel it endangers their hearing. They supported the availability of hearing protectors, and most importantly, 86% of the operators who tried protectors reported they would continue to use them in noisy environments.

There were some complaints, primarily to do with over-attenuation, comfort, and a feeling that protectors were not needed because noise was not a problem. Operators who said they had hearing problems, or those who were most frequently exposed to noise reported the most difficulties with protectors.

Mild weather conditions limited the value of the winter trial results and as a result a new, more in-depth, study of winter conditions is planned for 1982. Operators in the pre-questionnaires saw little need for hearing protectors while plowing snow. Again, there were indications that those with existing hearing difficulties and those most frequently exposed to noise would have the most difficulty adapting to protector use.

To summarize the findings of both trial use periods, it would seem that the operators involved in the study recognized some need for hearing protection. Operators support the availability of hearing protectors but want the decision to wear protectors left up to the individual. These points suggest the need of an education campaign to increase awareness of the noise problem and awareness of the need for hearing protection. No serious problems were reported with the use of hearing protectors. However, complaints were expressed about over-attenuation during certain activities. Finally, operators with existing hearing difficulties and those most frequently exposed to noise are likely to have the most difficulties adapting to the use of hearing protection.

1/ INTRODUCTION

1.1/ Background

Excessive noise levels in the work place can threaten the health and well-being of employees. Since it is not always practical or possible to eliminate excessive noise by engineering changes to equipment or to the work place, the use of personal hearing protectors is often necessary.

Recent studies dealing with hearing protector use have revealed some factors affecting protector effectiveness. Laboratory studies on the perception of warning sounds (Wilkins and Martin) [1] indicate that warning devices (e.g., bells, horns, etc.) that emit sounds which are very different from the background noise are quite easily identified while wearing hearing protectors. However, when danger is indicated by a change in the surrounding noise (e.g., change in pitch of machine noise), protectors interfere with perception. Taking into consideration the perception of warning sounds used by equipment operators to identify dangerous situations is, therefore, of concern when evaluating hearing protector use.

Studies of the intelligibility of speech indicate that for those with normal hearing, the use of protectors is not detrimental and may even enhance speech perception (Howell and Martin, 1975) [2]. However, persons with significant hearing loss may have a decrement in ability to understand speech while wearing protectors (Abel, Alberti and Rike, 1980) [3]. Thus, in assessing the impact of hearing protectors, it is important to review the hearing ability of the individuals involved.

Experience with a particular noisy job can affect adjustment to wearing hearing protectors. Employees frequently exposed to noise are often more in tune with the subtle changes in the surrounding noise and may find adjustment disconcerting. Also, the practicality of various types of hearing protectors is determined by the work environment, length of wearing time, and individual differences. All relevant factors must be considered in evaluating potentional problems and in matching the hearing protector with the person and his or her job requirements.

1.2/ Incentive for the Study

The Ministry of Transportation and Communications (MTC) Occupational Health and Safety Office is concerned about the exposure of highway equipment operators (Classes 1-4) to noise levels in excess of those legislated in the Occupational Health and Safety Act (90 dB over 8 h). Equipment operators are exposed to the noise of both equipment and high volume traffic and the Human and Social Systems Section (now Ergonomics Research) was asked to study the impact on the operators of wearing personal hearing protectors while carrying out their duties. Specific areas of interest were operator safety, ability to communicate and, secondarily, comfort and acceptance.

2/ METHODOLOGY

2.1/ Procedure

As a first step, an analysis was undertaken of typical equipment operator duties, and a breakdown was made of the MTC operator crews across the province by type of duties. On-site sampling of traffic and machinery noise levels for various operator tasks was conducted using a hand-held meter (Castle Model CS181A). The samples were collected during July and August, 1980, and were done to develop an understanding of typical work place noise. Readings from personal dosimeters (Bendix Noise Exposure System Model 1100) were also collected during this period but an equipment malfunction, revealed after the data collection, made the results unreliable.

Crews representing the more commonly occuring types found in the breakdown of duties were selected to take part in the study. Two crews of each type were selected and were then assigned to one of two groups. The operators in group one (experimental group) were asked to wear hearing protectors when near loud noise during a set trial period of time. They were supplied with both ear muffs (Silenta or Straightaway Model 805V) and ear plugs (E.A.R), and were free to use whichever type of protectors they preferred. The use of protectors was voluntary and a small number of the experimental group did not wear them or wore them infrequently. Operators assigned to group two (control group) were asked to pay particular attention to the noise around them. Some operators in this group already wore hearing protectors and they were <u>not</u> asked to reduce their wearing time.

There were two test sessions. The first session ran approximately from October 1 to November 31, 1980, and was to examine typical summer work conditions. The second session ran approximately from February 15 to March 15, 1981, and examined typical winter work conditions. A shorter winter session was used because operator duties then are much more specialized and primarily involve snow removal.

Information and opinions on the problems of noise and protector use were measured by pre- and post-questionnaires (see Appendix A). The partici-

pants were also asked to complete brief reports should an incident involving a safety or communication problem arise during the trial period (see Appendix B). These incident reports were to be completed by the experimental group operators when a problem occurred which they attributed to hearing protectors. The control operators were to complete a report when problems occurred because of noise.

The questionnaires were administered at meetings conducted by a research officer from the Human and Social Systems (Ergonomics Research) Office and a safety officer from the Regional Staff Safety Office. At the initial meetings, where pre-questionnaires were administered, the MTC hearing protection program was outlined, the fitting and use of hearing protectors was explained to operators in the experimental group, and incident reports were distributed. A second meeting was held after the trial period. At that time, post-questionnaires were completed, and group discussions took place concerning protector use and the noise problem. Because of shift work, not all the operators involved in the study could attend the meetings. When this was the case, extra materials were left for them and completed questionnaires were forwarded to the Human and Social Systems (Ergonomics Research) Office.

Audiometric testing of all employees is to be undertaken as part of the overall MTC hearing conservation program. Unfortunately, because this program is just beginning, and because one of the regional mobile testing units was damaged in a traffic accident, audiograms were not available for operators participating in this study. When this information becomes available, it is hoped it can be incorporated (with the consent of the individuals involved) into the study's findings in order to provide additional knowledge.

2.2/ Subject Selection

Highway equipment operators perform a wide variety of duties under many different environmental conditions. During summer months, the largest group of operators work in patrol units and are responsible primarily for highway maintenance. This involves such activities as repairing sections of highways, picking up garbage, and replacing guard rails. They use such equipment as compressors, rollers, graders, augers, and hand tools. The highways which the patrols service can be broken down into three

functional classifications: expressway, King's Highway, and secondary highway. This breakdown is determined by Ministry operational staff and is based, primarily, on traffic volume. Patrol activities on these highways are basically the same; but there is a difference in traffic noise.

In addition, each district has a number of special crews who perform specific tasks on all types of highways in the district. For example, the electrical crew replaces hydro poles and wiring, and installs signs; the forestry crew cuts trees, clears bush, and sprays weeds and trees with insecticide; and the zone painting crew strips old paint and paints new highway markings. The decision of which special crew types would be selected for participation in the study was based on the number of operators, across the province, in each type.

A total of 179 men, 98 in the experimental group and 81 in the control group, participated in the first trial-use session. The crew types involved were: patrol (expressway, King's Highway, secondary highway), zone painting, electrical, and forestry. Before crews were chosen to participate in the study, information was obtained on the type of equipment used, usual operator duties and traffic flow. Similar crews were paired with one crew of each pair being placed in the experimental and control groups.

During the winter months, the operators' highway maintenance responsibilities consist primarily of snow removal. For the most part, special crews are disbanded and assigned to patrol units. Typically, a two-man crew operates a snowplow truck with one driving and the other operating the plow wing. Communication is particularly important while plowing, both, within the plow truck and, on multiple-lane highway operations, between trucks via radio.

One hundred and eight persons (experimental group 52; control group 56) participated in the second trial-use session. The patrol units selected were chosen to represent slightly different areas of operations. The areas of operations included a heavily-used multi-lane highway, a heavily-travelled four-lane divided highway in a heavy snow area, and a two-lane undivided highway. Two patrol crews were chosen for each of the three areas with one crew being assigned to the experimental group and

the other to the control group. No patrol crews used in the summer trial session were used again in the winter session.

2.3/ Instruments

Information was collected through the use of pre-questionnaires, post-questionnaires, incident reports, and group discussions. The pre-questionnaires requested information on the operators' characteristics and on evaluation issues. The questions on the operators' characteristics dealt with demographic information such as age, job type, patrol number, current hearing problems, and frequency of exposure to loud noise. Issues that were important to the evaluation included difficulties in communication, safety, and comfort currently resulting from noise and difficulties expected to result from the use of hearing protectors; and attitudes toward the use of hearing protectors. Specific items touching on communication issues dealt with such topics as hearing instructions, conversation, in-truck radios, and changes in equipment noises. Safety items dealt with the ability to hear such things as warning shouts and signals. Comfort items dealt with annoyance and ability to concentrate, for example.

The pre-questionnaires of the control and experimental groups differ only in minor phrasing, i.e., the experimental subjects were informed that their crew would be asked to wear hearing protectors, then the protectors were briefly described. The post-questionnaires closely paralleled the pre-questionnaires, with the addition of questions related to the use of protectors. The questionnaire items were primarily of the checklist type. This format was chosen because it is quicker and easier to complete and the responses are more easily quantified.

The incident report form requested such information as: type and description of incident, persons involved, equipment operated, use of hearing protectors, and supervisors' comments.

The group discussions took place with each crew following completion of the post-questionnaires. Not all the operators could take part in the discussions due to shift work, illness and vacation time. The operators were asked how they felt about hearing protection and what they thought others felt about it. The operators' responses were recorded and compared with those from other crews.

3/ RESULTS

3.1/ Noise Level Measures

Due to the greater variety of summer operations and therefore the greater variety of noise, noise levels were sampled only for this period. Noise during winter operations consists almost exclusively of truck and truck equipment (plow, wing, radio). However, in-cab measures of truck noise were included in the summer measurements.

The noise level measurements, sampled on-site, revealed that noise levels often exceeded the allowable limits of 90 dB. Machinery noise ranged from 78 to 104.8 dB, and traffic noise ranged from 67.8 to 92 dB. The noisiest machine, recorded at 104.8 dB, was the 'Chipper' used by forestry crews. Table 1 details the range of noise levels recorded for the crews tested.

3.2/ Summer Session Results

3.2.1/ Pre-Questionnaire for the Summer Session

Examination of the mean ages and years of experience, for both the experimental and control groups, showed no significant differences. This, coupled with the fact that crews were selected for similar work environments, suggests the groups were reasonably well matched.

Most of the operators taking part in the summer session reported they were exposed to loud noise for part or for most of each day while at work, and once a week or less in leisure time. Forty-one percent had worn hearing protectors (nearly all of these used muffs) sometime prior to the two month trial period. Fifty-two percent of the control group and 71% of the experimental group believed that noise might be damaging to their hearing. Those most often exposed to noise in their work found the noise least distracting, but many of them had also worn hearing protectors.

The question inquiring whether the respondent had ever been accused of being hard of hearing was answered affirmatively by 29% of the experi-

mental subjects and by 11% of the control subjects. Interestingly, the answer was not linked to age or years of experience. Those operators who said they had been accused of having hearing problems more often claimed difficulty in hearing changes in machinery noise, difficulty with general safety, and less distraction resulting from noise. The two other questions on hearing problems were answered affirmatively by a very small percentage of the subjects.

On items concerning the amount of difficulty that noise causes in safety and communications, the majority (60%) of the answers fell in the categories of a little difficulty or very difficult. The items relating to comfort yielded mixed results. The answers are almost evenly split between the categories. Seventy percent of the experimental subjects and 44% of the control subjects made comments explaining how they felt general safety is affected by noise. The major concerns were: loss in communication of instructions; distraction or disturbance of concentration; failure to hear approaching traffic; and failure to hear warning shouts. Some differences surfaced when patrol type was taken into consideration. Secondary Highway and King's Highway crews, who perform basically the same duties on low traffic volume roadways, reported few problems with noise affecting their work. Expressway and specialty crews (zone paint, forestry, electrical), who must contend with more traffic and/or equipment noise, reported more difficulties.

Questions concerning work-related accidents revealed that about half the respondents have seen accidents occur, but very few blame excess noise (4% of the controls and 8% of the experimentals). Consequently, the questions of why the respondent felt noise helped cause the accidents yielded few answers. Of these answers, the main reasons stated were: the individual could not hear warning shouts and entered a dangerous situation; and that the distraction of the noise caused a dangerous lapse in concentration (examples of these types of comments are: "the sudden noise caused the accident" and "the person could not concentrate because of noise").

Nearly all respondents support the availability of protectors to workers (fewer than 2% said no). Sixty percent favoured compulsory use in high-

noise-level work areas. The most common concern checked by those disagreeing with compulsory use, was that of increased danger, followed by difficulty in communications. Examples of additional comments written are: danger in not hearing oncoming traffic; uncomfortable nature of muffs; and the belief that it is the individual's right to risk hearing damage.

Questions regarding the expected effect of hearing protector use revealed no clear pattern of opinions. On the expected comfort of protectors the answers ranged across all categories. Protectors were expected to help prevent hearing loss and aid concentration, but they were also seen as somewhat of a threat to communication and safety. Answers to the request for additional comments on the expected effects of protectors reflected the same range of comments as previously listed for compulsory use.

3.2.2/ Post-Questionnaire

The return rate for the post-questionnaires was 80%. Nineteen operators in the control group and 17 in the experimental group did not return post-questionnaires. The non-returnees were spread fairly evenly across the various groups and crew types and, therefore, they are not believed to have had a significant effect on the results.

Post-questionnaire results indicate that there was a high level of cooperation from the operators involved in the study. Comparisons were made to check how often the study participants had previously worn protectors compared to how often protectors were worn during the study (Tables 2a and 2b). In the experimental group, with only two exceptions, all participants maintained or increased their frequency of use. Indeed, of those who reported never wearing hearing protectors before the study, 72% wore them at least some of the time during the trial period. In the control group, there was little change in the frequency of use.

The type of protector most commonly worn by the two groups both before and during the study, were muffs. Protectors were worn most frequently around noisy equipment, although a combination of noisy equipment and traffic was also a reason frequently given for use.

Operators in the experimental group who reported they did not always wear hearing protectors were asked to give their reason(s) and they could check off as many reasons as they felt applied to them. Table 3 gives an overall look at the ranking of these reasons. Most prominent were comfort problems and a feeling that noise was not a problem.

Both control and experimental group operators who had tried hearing protectors were asked if they would prefer to continue using protectors in a high-noise environment; 91% and 86%, respectively, responded affirmatively. When asked why, the majority of reasons given by those who would continue using protectors centered around health, job safety, and comfort. The few operators who would not continue wearing their protectors gave reasons such as: the noise was not bothersome, hearing protectors presented a safety hazard, and they were too uncomfortable. The responses regarding continued use of protectors were consistent across the various crew and patrol types.

3.2.3/ Pre-Post-Questionnaire Comparisons

In the post-questionnaire, the operators were again asked to note the amount of difficulty noise caused in their work in order to verify that the noise characteristics of the work environment, during the study, were not atypical. The pattern of results was similar to that of the pre-questionniare. The majority of operators felt that noise causes some safety and communications problems. Opinions pertaining to the effects of noise on personal comfort and concentration were mixed.

The control group (who had been asked to pay particular attention to the noise around them) shifted from generally describing the noise as causing no difficulty to causing a little difficulty. This was not a strong shift.

The control and experimental groups were asked again in the post-questionnaire for their opinions of the effects of hearing protectors on safety, communications, and comfort. The majority of the control group, as before, could only base their response on what they felt were the expected effects of protectors, whereas the majority of the experimental group now had some experience with them. Frequency scores and cross-tabulations between pre- and post-questionnaire items showed little

change from the pre-questionnaire responses. This held true for different patrol types. The only slight trend observed was for those in the experimental group who had tried protectors (some of the time, most of the time, always); to report that protectors had the effect of making things a little more difficult. In the pre-questionnaire they had felt that the effect would be to cause much more difficulty. This was evident with the questions dealing with comfort, the ability to hear warning shouts, and the ability to hear important changes in equipment noises. These results suggest that the control group's opinions have not changed over the time between questionnaires, and the experimental group's opinions have improved slightly after their use of protectors.

Both groups continue to strongly support the availability of hearing protectors (control group, 93%; experimental group, 90%), but responses to the questions of compulsory use show some change. The control group's pre-questionnaire results showed 56% were in favour of compulsory use and 39% felt the decision of when to use hearing protectors should be up to the individual. In the experimental group, 66% were for compulsory use and 31% were for individual decision. In the post-questionnaire results, 36% of the control group favoured compulsory use and 61% favoured individual decision. Forty-three percent of the experimental group were for compulsory use and 51% were for individual decision. This shift to increasing support for individual decisions on the use of protectors seems to be general and not specifically related to patrol type. In the control group, the largest shifts occurred for the King's Highways, forestry, and electrical crews. In the experimental group, the largest shifts occurred for expressways and secondary highways crews.

As before, very few of the operators rejected the use of protectors completely. The amount of time that operators now wear hearing protectors influences their feelings towards compulsory use. Those who always wear hearing protectors favour compulsory use, while those who wear them some or most of the time feel the decision should be up to the individual.

In the pre-questionnaire, 29 of the experimental group and nine of the control group reported that at some time they had been accused of being hard-of-hearing. Of these 38 operators, only the post-questionnaire

responses of those in the experimental group could be analysed, as too many of the nine operators in the control group did not return their post-questionnaires. In the post-questionnaire, the self-reported hard-of-hearing group reported more difficulties with noise when not wearing protectors; particularly, on items to do with communications and safety (Table 4). While wearing hearing protectors, the hard-of-hearing group reported more difficulties in their ability to hear instructions, warning shouts, warning signals, changes in equipment noise, and in their ability to concentrate (Table 5). They were also more likely to say that they would choose not to wear protectors because they had difficulty in identifying equipment noise and so thought the protectors made their work more dangerous.

The pre-questionnaire also identified some differences for those most often exposed to noise. They found the noise less distracting and more frequently they already used hearing protectors. The post-questionnaire results showed that members of the experimental group, who experience on-the-job noise for most of each day, or once a week or less, more often feel that the use of protectors should be left up to the individual. They also more often report that they would not prefer to continue using protectors after the study. Operators exposed to noise part of each day, or three to four days per week, showed stronger support for compulsory use and continued use for themselves. Those frequently exposed to noise reported more complaints about the weight of protectors and about the difficulty of identifying changes in equipment sounds, but on other items their responses were similar to those of other operators.

3.2.4/ Incident Reports

No incident reports were completed during the two month period.

3.2.5/ Group discussions - General Observations

After the post-questionnaires were completed, an informal group discussion was held with each crew. To a large extent the comments reflected the responses given in the questionnaires. Additional complaints concerned the weight of ear muffs and the fact that they pressed too hard on the head causing headaches. Most of the operators were in favour of or

neutral about the use of protectors, but there were some who expressed strong negative feelings. These negative feelings centred primarily on concerns about safety.

For the most part, the protectors seemed to be a minor annoyance. There were, however, two notable exceptions. Crews on low traffic volume roads (secondary and King's Highways) reported that when the operators wore hearing protection, cars were difficult to hear as they came up to the work site. This was noted particularly during flagging operations. Trucks could still be heard as they approached, but not cars.

The other problem was brought to the attention of the Occupational Health and Safety Staff directly. It occurred on a cold fall day. Members of a patrol were doing road repairs using a jack hammer and were wearing ear muffs. After the repairs were completed and noise was no longer a problem, they removed their muffs and continued working. However, moisture had collected in their ear canals while the muffs were worn; this, and the cold conditions caused some crew members to develop ear aches. This situation was brought to the attention of the muff manufacturer so that a solution to the problem could be found.

3.3/ Winter Session Results

Comparison of the mean ages of the experimental group (mean = 42.2) and the control group (mean = 44.7) showed no significant difference. Years of service could not be calculated in this case because of the larger number of seasonal employees. Over 50% of the operators questioned said they were exposed to loud noise for part or most of each working day. Exposure to noise during leisure time was reported much less frequently. More than half the operators (62%) reported that noise caused some difficulties in the areas of giving and hearing spoken instructions, hearing warning shouts, and hearing radio communications. Only slightly less than half (44%) reported difficulties with giving warning shouts, hearing warning signals, hearing important changes in equipment sounds, and general safety.

The majority also said the noise was, to some extent, annoying, uncomfortable, and distracting. Forty-seven percent of the operators felt

that the noise was damaging their hearing. Very few of the operators (6.5%) reported having been involved in accidents that they felt were linked to excessive noise. The reasons given for these accidents were that instructions or warnings could not be heard.

Only 16.7% of the operators reported wearing protectors at the time of the study. Of these, 28% always wear them, 28.5% wear them frequently, and 39% wear them occasionally. Muffs are the most frequently worn protectors, and noisy equipment is the most common reason for wearing them. It is very unlikely that protectors were worn while plowing snow and these reports probably reflect protector use during the summer season.

Most of the operators (72.2%) felt that protectors should be available, but only 4.6% felt they should be required when plowing snow. The majority felt the decision to wear protectors should be up to the individual. The next item on the questionnaire asked why the operators felt that compulsory use was not a good idea. The most frequent reasons given were: "They would make my work more dangerous" and "I would not be able to talk to others."

The operators felt that the protectors would interfere more with their ability to hear instructions, warnings, and changes in equipment noise, rather than with their comfort, conversation or concentration. For example, 82.4% felt that protectors would make it a little more, or much more difficult to hear instructions while only 58.3% felt that protectors would make their comfort a little worse or much worse.

The winter session operator sample is made up of a number of sub-groups and the questionnaire results for the various sub-groups were examined separately. There was very little difference in the results of the experimental group compared to the control group. On almost all items, response totals did not vary by more than 10% and no consistent trends emerged. There were some differences between different patrol types. As was noted in Section 2, Methodology, two crews servicing a six-lane highway near an urban centre, two crews servicing a busy rural four-lane divided highway, and two crews servicing a rural two-lane highway took part in the study. One crew member of each pair was placed in the experimental group; the other in the control group. Not unexpectedly, the

rural two-lane crews members reported fewer noise-related problems. They reported less difficulty giving spoken instructions, hearing spoken instructions, giving warning shouts, hearing warning shouts, and hearing radio communications. They less frequently reported the noise was annoying.

The rural two-lane crews also differed slightly in their opinions towards the expected effects of hearing protectors. They more often thought that protectors would cause difficulties in hearing instructions and hearing important changes in equipment sounds. Members of the rural four-lane crews more often reported that noise was distracting; they less often favoured the availability of hearing protectors and more often thought protectors would improve concentration.

Three questions on the pre-questionnaire asked the operators to report any problems they currently have with their hearing. Fifteen of the operators (14%) reported that they had been accused of being hard of hearing, 10 reported having trouble hearing people speak even in a quiet place, and six reported that they must turn the television or radio up very loud. As in the pre-questionnaire for the summer session, the affirmative responses to the questions about hearing problems were not related to age or years of experience.

Upon further analysis, the 15 who reported they had been accused of being hard of hearing, proved to be a quite distinct group. A composite group, made up of anyone who answered affirmatively to any of the three questions, was created; but this group did not appear to differ markedly from the total group of operators. Operators who acknowledged having been accused of being hard-of-hearing, more often reported that in the work place noise causes difficulty for them when giving warning shouts, hearing warning shouts, and hearing important changes in equipment noise. They also reported noise as being more annoying, more uncomfortable, and more distracting to concentration, but less painful. These operators more often thought that noise may be damaging their hearing; less often do they already wear protectors (6.7% to 18.3%); but more often they supported compulsory use of protectors while plowing snow (13.3% to 3.2%).

The responses of operators who reported being around noise most or part of each day were compared to those reporting less frequent exposure to noise. Operators who were more frequently around noise, reported less difficulty with it. They more often thought it was damaging their hearing, more often already use protectors, and favour the availability of protectors.

The operators were also grouped by years of experience and their responses compared. Results from this grouping showed marked trends. Those operators with more years of service more often thought noise was damaging their hearing; were more often in favour of making protectors available; and more often supported compulsory use of the protectors while plowing snow. Finally, the operators were asked for their general comments about noise and hearing protectors. The most common responses were that the use of protectors should be up to the individual, and that protectors would help in noisy areas.

Unfortunately, at approximately the same time as the winter trial-use period began, the weather turned unseasonably mild. After mid-February (the period's starting date) very little additional snow fell. The mild weather meant that considerably less snow plowing was done than usual, and also that some seasonal staff on the patrol crew left their employment at MTC before their usual time and were lost from the study. Twenty-four operators in the control group and 18 in the experimental group did not return post-questionnaires. Unfortunately, due to the termination of seasonal contracts, a greater percentage of the crews servicing rural four-lane highways failed to return a post-questionnaire in comparison to the other patrol types. This high no-return forces most post-questionnaire data comparisons to be made between control and experimental groups only.

For the above reasons the post-questionnaire results, the pre- and post-questionnaire comparisons, and the group discussion reports are of questionable validity. Therefore, all additional data from the winter trial period have been placed in Appendix C and are presented for informational purposes only.

A further study of noise and hearing protection problems while plowing snow has been scheduled for the winter of 1982. At that time subjective measurements of the impact of hearing protectors will again be taken, an analysis of in-cab noise levels and operator exposure to noise will be done, and the audiometric testing of the operators involved will be carried out. It is hoped that this study will provide a more complete look at the noise problem and the impact of hearing protectors.

4/ CONCLUSION

4.1/ Study Findings

The preliminary phases of the study showed a wide range of the operators' duties and a wide range of noise levels to which they are exposed. Although these noise readings were only preliminary samples and not a scientific collection of noise exposure data, they do serve to indicate the scope of the problem. The noise levels fall on both sides of the legislated danger point of 90 dB. There is a definite risk from some equipment and work places, but there is also a large group of locations and equipment which are safe. This is particularly true under summer conditions when proximity to the highway and the type of equipment used, are constantly changing.

Summer Session

The general indications from the results favour the implementation of some type of hearing protection program for summer working conditions. Workers acknowledge that they are frequently exposed to loud noise and that noise causes difficulties. It is regarded by many as dangerous to their hearing. The operators report some difficulities in the areas of safety and communication. This is particularly true for expressway and specialty crews, and it is not surprising, given the high noise readings measured for those types of crews. However, operators seem to have adapted to the noise. For example, those most often exposed to work noise less often reported being distracted by it. They are probably accustomed to loud noise as it has become part of the usual work environment. Operators who acknowledged accusations of being hard-of-hearing less often reported being distracted and it is possible their hearing loss insulates them from excessive noise.

Virtually all the operators surveyed support the availability of hearing protectors, which suggests that the need for protection is recognized. That operators also seem motivated to use protectors, is suggested by their high level of co-operation with the study, particularly with the trial use of protectors. This is encouraging, for it suggests that there is no great resistance to be overcome before a hearing protection program could be successfully implemented.

It is most encouraging that 86% of the operators who tried protectors during the study period reported they would continue to use protectors when in a noisy environment. It should be pointed out that many of these operators had not previously tried protectors. Although it would be naive to expect all 86% to continue using protectors on their own, it at least demonstrates the acceptability of protectors.

Although the availability of protectors was almost completely supported, compulsory use was less strongly supported. In the pre-questionnaire, the majority supported compulsory use; but in the post-questionnaire, the majority felt the decision of when to use protectors should be left up to each individual. This may reflect an individual's natural desire to have the right to make his own decision, or it may reflect the operators' recognition that the work environment is not constant and, therefore, there is a need for flexibility in the use of protectors. In either case, the findings indicate a need for an educational program demonstrating the benefits of hearing protectors. Those operators who consistently wore their protectors were more frequently in favour of compulsory use. This supports the findings of other studies that regular use helps people become accustomed to protectors.

There were, of course, a number of complaints about the protectors. No incident reports were completed and this suggests that there were no problems, or that they were not of a serious nature. Comments made in the group discussions suggest that over-attenuation may be a problem on some operator jobs. For example, the rural crew said they were not able to hear approaching cars when wearing muffs. This problem of over attenuation may well exist in all low-noise situations.

The more commonly given reasons for not wearing muffs were discomfort and the belief that noise is not a problem. The problem of discomfort may be reduced as the operators wear protectors more frequently and become accustomed to them. Again, a strong educational campaign would help correct the belief that noise is not a problem. Concerns about safety and about the ability to communicate were less frequently expressed, and seem to be of less concern after protectors have been tried. Differences in the results on pre- and post-questionnaire items dealing with the effects of hearing protectors were slight. For the control group, this suggests that nothing occurred during the study which affected the

operators' opinions. The experimental groups' opinions of hearing protectors did not become worse and in some respects they improved.

Certain groups of operators had slightly different reactions to protectors. Previous laboratory studies had suggested that persons with an existing hearing loss would have more difficulty in using protectors. This seems to be borne out in the trial use study. If it is accepted that self-reports of hearing loss are closely linked to actual hearing loss (this could be verified when the audiometric testing is complete), then the study results suggest that extra consideration must be made for workers who have existing hearing loss when the use of protectors is implemented.

The findings also suggest that the amount of exposure to noise affects opinions about hearing protectors. Those operators most frequently exposed to noise showed more support for protectors; therefore, any campaign to increase protector use should place more emphasis on those operators who are less frequently exposed to noise. Operators more frequently exposed to noise reported more difficulties when using protectors. This also had been suggested by previous studies. It was stated that those with more experience of working in a noisy environment would require a longer time to adjust to the effects of protectors. This, also, should be considered in the implementation of hearing protection programs.

Winter Session

The mild weather conditions during the study resulted in a decrease in the number of times that protectors could be used, and a consequent loss in the number of subjects in the study. Quite probably, this had a strong effect on the results and they should be interpreted with caution.

A main point derived from the winter session results is that the majority of operators see little need for the use of hearing protectors while plowing snow. The operators did report that they were frequently exposed to noise and that it causes some difficulties. However, there was con-

siderably less support (compared to the summer session) for making protectors available and for making their use compulsory. Even in the pre-questionnaire, almost all the operators felt the use of protectors should be a personal decision. Few of the snow plow operators reported that they would continue to use protectors once the study was over. These findings suggest that implementing the use of hearing protectors for winter season activities will be difficult. The study which is proposed to examine winter conditions specifically may help in this area.

Two distinct subgroups (the self-reported hard-of-hearing group and the operators frequently exposed to noise) could again be identified in the pre-questionnaire results. Unfortunately, the number of respondents to the post-questionnaire was too small for the data to be divided into subgroups. As in the summer session, operators who reported having been accused of being hard of hearing emerged as an identifiable subgroup. Although their complaints were somewhat different from the same group in the summer session, the suggestion again appears that operators with a hearing loss will have special problems adapting to protectors. The other group which stood out as distinct from the majority of operators, involved operators who were around loud noise for part or most of each day. As with their counterparts in the summer session, this group reported fewer problems with noise. Again, it would seem that this group has adapted to the noise around them and may react somewhat differently when asked to adapt to protectors.

In conclusion, the main findings are that, for summer work, the majority of equipment operators in this study favour the availability of hearing protectors, but would like to make their own decisions about when to use them. The operators recognize some need for protectors. The use of hearing protectors in a two month trial gave rise to no serious problems. The most pressing problem appears to be over-attenuation in low-noise environments such as rural roads. The difficulties that the operators reported with the use of hearing protectors are summarized in Table 6. They are combined under the three evaluation issues of safety, communications, and comfort. Operators suffering from existing hearing loss are likely to have additional problems in adapting to the use of protectors. For snow plowing, the majority of operators do not see a need for hearing protectors. This, in turn, suggests the need for further testing and a strong education campaign.

5/ REFERENCES

[1] Wilkins, P.A. and Martin, A.M., "The Effect of Hearing Protectors on the Perception of Warning Signals - A General Review," Technical Report 98, Institute of Sound and Vibration Research, University of Southampton, England.

[2] Howell, K. and Martin, A.M., "An Investigation of the Effects of Hearing Protectors on Vocal Communication in Noise," Journal of Sound and Vibration, 1975 41(2), pp. 181-196.

[3] Abel, S.M., Albert, P.W., and Riko, K., "Speech Intelligibility in Noise with Ear Protectors," Journal of Otolaryngology, 1980, 9:3, pp. 256-265

[4] Miller, R.K., Handbook of Industrial Noise Management, Fairmont Press, Atlanta, 1976, 210 p.

[5] Olishifski, J.B., Industrial Noise and Hearing Conversation, National Safety Council, Chicago, 1975, 1120 p.

Table 1/ Noise Level Recordings (in dB) for Summer Operations

	NOISE SOURCE	
Crew Type	Machinery Range	Traffic Range
Expressway	80 - 102	78 - 92
King's Highway	93 - 96	73 - 82
Zone Paint	79 - 90	76 - 86
Electrical	78 - 96	68 - 84
Forestry	81 - 105	73 - 87
TOTAL	78 - 105	68 - 92

Table 2a/ A Comparison of the Wearing Frequency of Hearing Protectors: The Period Before the Study vs the Summer Trial-Use Period

Experimental Group

	Wearing Time During the Trial-Use Period				
Wearing Time Prior to the Study	always	most of the time	some of the time	never	Total
always	100% (N=5)	-	-	-	100% (N=5)
most of the time	21.4% (N=3)	64.3% (N=9)	7.1% (N=1)	7.1% (N=1)	100% (N=14)
some of the time	12.1% (N=4)	12.1% (N=4)	75.8% (N=25)	-	100% (N=33)
never	20.% (N=5)	12.8% (N=3)	40.0% (N=10)	28.0% (N=7)	100% (N=25)

Table 2b/ A Comparison of the Wearing Frequency of Hearing Protectors: The Period Before the Study vs the Summer Trial-Use Period

Control Group

	Wearing Time During Trial-Use Period				
Wearing Time Prior to the Study	always	most of the time	some of the time	never	Total
always	66.7% (N=2)	-	-	33.3% (N=1)	100% (N=3)
most of the time	-	83.3% (N=5)	-	16.7% (N=1)	100% (N=6)
some of the time	-	20.0% (N=3)	53.3% (N=8)	26.7% (N=4)	100% (N=16)
never	3.3% (N=1)	3.3% (N=1)	-	93.3% (N=28)	100% (N=30)

Table 3/ Why Operators Chose Not to Wear Hearing Protectors

Rank	N	Reason for Not Wearing Hearing Protection*
1	31	I found them heavy.
2	30	The noise did not occur often enough to bother me.
3	26	I didn't think the noise was hurting me.
4	24	I didn't mind the noise.
5.5	23	I couldn't hear people talking to me.
5.5	23	I though they made my work more dangerous.
7	22	I found them hot.
8	18	I found the pressure of the muffs on my ear too great.
9.5	16	I thought I would miss important instructions
9.5	16	I had difficulty in identifying equipment sounds.
11	13	I forgot to wear them.
12	11	I had difficulty in locating sounds.
13	9	I found them painful.
14.5	6	I didn't like the strange sound I heard.
14.5	6	I didn't know I was required to.
15	5	I didn't think it was important since other workers did not always wear them.
16.5	4	I didn't like the appearance of them.
16.5	4	They didn't fit properly.
18	2	I found they didn't help shut out the noise.

* Respondents could give more than one response.

Table 4/ The Amount of Difficulty Caused by Noise When Not Wearing Protectors: Operators Reporting Hearing Problems vs Operators Not Reporting Hearing Problems

Experimental Group

Difficulty Caused by Noise When Not Wearing Protectors	Operators Reporting Some Hearing Problems			Operators Not Reporting Hearing Problems		
	no difficulty	a little difficulty	much difficulty	no difficulty	a little difficulty	much difficulty
giving spoken instructions	11%	72%	17%	26%	53%	16%
hearing spoken instructions	11%	72%	17%	21%	55%	18%
giving warning shouts	17%	72%	11%	38%	33%	18%
hearing warning shouts	6%	78%	17%	39%	23%	28%
hearing warning signals	22%	78%	0%	39%	23%	28%
conversation	6%	77%	12%	18%	58%	16%

Table 5/ The Amount of Difficulty Caused by Wearing Hearing Protectors: Operators Reporting Hearing Problems vs Operators Not Reporting Hearing Problems

Experimental Group

Difficulty Caused by Hearing Protectors	Operators Reporting Some Hearing Problems		Operators Not Reporting Hearing Problems	
	a little * more difficult	much more * difficult	a little more difficult	much more difficult
ability to hear instructions	55%	10%	39%	17%
ability to hear warning shouts	48%	7%	37%	13%
ability to hear important changes in equipment noise	45%	10%	41%	9%
ability to concentrate	38%	0%	11%	6%

* Items originally included more than two choices, therefore, table results do not total 100%

Table 6/ Evaluation Issues

Evaluation Issues	Operator Groups Reporting Problems While Wearing Hearing Protectors	Type of Problem
Safety	Summer Session (1) Rural crew (2) Self-reported hard-of-hearing group (3) Those frequently around loud noise	hearing approaching cars hearing warning shouts, warning signals, hearing changes in equipment noises
	Winter Session* (1) Experimental group as a whole	hearing changes in equipment noises.
Communications	Summer Session (1) Self-reported hard of hearing	hearing instructions.
	Winter Session* (1) Experimental group as a whole	hearing conversation (between driver and wingman), radio, passing trucks
Comfort	Summer Session (1) Self-reporting hard of hearing (2) Those frequently around loud noise	ability to concentrate weight of protectors
	Winter Session* (1) Those infrequently around loud noise	ability to concentrate

*Note: Winter session information is suspect.

APPENDIX A

CONFIDENTIAL

Noise and Hearing Protection Survey (A)

The Occupational Health and Safety Office wants to find out more about the problem of noise in the work place. We of Research and Development have been asked to look into the problem. We are interested in what you think about the noise problem and the use of hearing protection (ear muffs or ear plugs).

Please answer all questions honestly and truthfully. We do require your name so that your experiences over the next 2 months can be compared.

Your completed questionnaire is confidential. It will not be shown to your supervisor, nor will it be in employee records. The information is strictly for our research on noise and hearing protection. Complete information is vital for us to effectively protect your hearing while on the job, and to enable us to detect any problems so that they can be dealt with.

Personal Information:

Name: _____

Date of Birth: _____

Job Title: _____ Type of crew: (check one)

Patrol _____
Forestry _____
Electrical _____
Zone Paint _____
Other (Explain) _____
_____

Region _____

District _____

Yard _____

Instructions For each question, put a check (✓) in the appropriate space (_). Write additional information when it is asked for.

Has anyone ever accused you of being hard of hearing? Yes ____ No _____

Do you have trouble hearing people speak, even in a quiet place? Yes ____ No _____

Do you find you must turn the TV or radio up very loud for you to hear it? Yes ____ No _____

Please check how often you are around loud noise:

	Most of the day	Part of each day	3 to 4 days a week	Once a week or less
in your work	_____	_____	_____	_____
in your leisure time	_____	_____	_____	_____

Loud noise can sometimes make it difficult to work. Please check the amount of difficulty that noise causes in your work for each task below:

Task	Difficulty		
	The noise causes no difficulties	The noise makes this a little difficult	The noise makes this very difficult
giving spoken instructions	_____	_____	_____
hearing spoken instructions	_____	_____	_____
giving warning shouts	_____	_____	_____
hearing warning shouts	_____	_____	_____
hearing warning signals (back-up signals, car horns, etc.)	_____	_____	_____

In the next while, your work crew and many others will be given hearing protection devices (ear muffs or earplugs) to wear when working near loud noise. They are carefully designed specially for the worker, and muffle background noise to protect against hearing damage.

Do you now use some type of hearing protectors at work? Yes ____ No ____
If yes, what type? _____

Do you think it is a good idea to have these protectors available to workers?

Yes _____ No _____

Do you think that it is a good idea for these protectors to be <u>required</u> to be worn in areas of high noise?

Yes _____

No _____

Should be up to each person _____

If you did not say yes, could you tell us why you believe required use is not a good idea?

They would make my work more dangerous _____

I would not be able to talk to others _____

Other reasons _____

(Please explain)_____

_____

How do you think wearing hearing protection would affect each of the following:

	Make it much easier	Make it a little easier	No Effect	Make it a little more difficult	Make it much more difficult
Comfort	____	_____	____	_____	_____
Preventing hearing loss	____	_____	____	_____	_____
Conversation with fellow workers	____	_____	____	_____	_____
Ability to hear instructions	_____	_____	_____	_____	_____
Ability to hear warning shouts	_____	_____	_____	_____	_____
Ability to hear warning signals	_____	_____	_____	_____	_____
Ability to hear important changes in equipment noise	_____	_____	_____	_____	_____
Ability to concentrate	_____	_____	_____	_____	_____
Other (Please explain)	_____	_____	_____	_____	_____

_____

_____

Task	Difficulty		
	The noise causes no difficulties	The noise makes this a little difficult	The noise makes this very difficult
hearing important changes in the sound of your equipment	_____	_____	_____
conversation	_____	_____	_____
concentration on your work	_____	_____	_____
physical comfort	_____	_____	_____
radio communication	_____	_____	_____
general safety on the job	_____	_____	_____

(Please explain how you think safety is affected by noise)

_____

_____

Have you ever been involved in or seen any accidents at work? Yes ____ No ____

If yes, do you think that loud noise was somewhat responsible for the accident?

Yes _____ No _____

If yes, could you please say why you think it was?

_____

_____

In your work around loud noise, do you personally find the noise:

	Not at all	A little	Very	Extremely
annoying?	_____	_____	_____	_____
uncomfortable?	_____	_____	_____	_____
distracting to your concentration?	_____	_____	_____	_____
painful?	_____	_____	_____	_____

Do you think the noise may be damaging to your hearing? Yes _____ No _____

APPENDIX B

INCIDENT REPORT

Type of Incident: Communications ___ Safety ___

H.O. DIV/REG. SECT./DIST. _____

SECT./PAT./ETC. _____

Name _____ Age_____

Classification _____Position _____

Hearing Protection Worn Yes _____ No _____

If Yes, Type _____

Date of Incident _____Time _____ A.M. ___ P.M. ___

Incident Site _____

_____

Description of Equipment used _____

_____

Other persons involved Name _____

Classification _____ Position _____

Hearing Protection worn Yes _____ No _____

Name _____

Classification _____ Position _____

Hearing Protection worn Yes _____ No _____

Description of Incident _____

_____

_____

_____

_____

Supervisor's Comments _____

_____

_____

(for additional comments use other side)

CONFIDENTIAL

Noise and Hearing Protection Survey (B)

The Research and Development branch of MTC thanks you for cooperating in the Noise and Hearing Protection Program. We would now like you to think about the past 2 months on the job.

Please answer all questions honestly and truthfully. We do require your name so that your experiences over the past 2 months can be compared.

Your completed questionnaire is confidential. It will not be shown to your supervisor, nor will it be in employee records. The information is strictly for our research on noise and hearing protection. Complete information is vital for us to effectively protect your hearing while on the job, and to enable us to detect any problems so that they can be dealt with.

Personal information:

Name _____

Date of Birth _____

Job Title _____ Type of Crew: (Check one)

Patrol _____

Forestry _____

Region _____

Electrical _____

District _____

Zone Paint _____

Yard _____

Other (Explain) _____

_____

Instructions: For each question, put a check ( ) in the appropriate space (__). Write additional information when it is asked for.

Loud noise can sometimes make it difficult to work. Please think of the PAST 2 MONTHS and check the amount of difficulty when you were NOT WEARING HEARING PROTECTORS for each task below.
Check here and skip to next page if you always wore hearing protectors near loud noise. _____

Task	The noise causes no difficulties	The noise makes this a little difficult	The noise makes this very difficult
giving spoken instructions	_____	_____	_____
hearing spoken instructions	_____	_____	_____
giving warning shouts	_____	_____	_____
hearing warning shouts	_____	_____	_____
hearing warning signals (back-up signals, car horns, etc.)	_____	_____	_____
hearing important changes in the sound of your equipment	_____	_____	_____
conversation	_____	_____	_____
concentration on your work	_____	_____	_____
physical comfort	_____	_____	_____
radio communication	_____	_____	_____
general safety on the job	_____	_____	_____

(Please explain how you think safety is affected by noise)

_____

_____

Hearing Protection Use

Please think back to your experiences on the job BEFORE YOU FILLED OUT THE FIRST QUESTIONNAIRE, that is AUGUST, 1980.

How often did you wear hearing protectors when working near loud noise?

Always _____

Most of the time _____

Some of the time _____

Never _____

Under what circumstances did you wear them?

When working with noisy equipment _____

When working near noisy traffic _____

In both of the above circumstances _____

What type did you wear? ear muffs _____

ear plugs _____

Both _____

Please think back to your experiences on the job SINCE YOU FILLED OUT THE FIRST QUESTIONNAIRE, that is OVER THE PAST TWO MONTHS.

How often did you wear hearing protectors when working near loud noise?

Always _____

Most of the time _____

Some of the time _____

Never _____

Under what circumstances did you wear them?

When working with noisy equipment _____

When working near noisy traffic _____

In both of the above circumstances _____

What type did you wear? ear muffs _____

ear plugs _____

Both _____

People may choose at times not to wear hearing protection devices. If you did not always wear then when around noise, could you tell us why? Please check as many as are true for you.

I didn't know I was required to _____

I didn't think it was important, since other workers did not always wear them _____

I didn't mind the noise _____

I didn't think the noise was hurting me _____

The noise did not occur often enough to bother me _____

I found they didn't help to shut out noise _____

I forgot to wear them _____

I thought I would miss important instructions _____

I couldn't hear people talking to me _____

I didn't like the appearance of them _____

I found them hot _____

I found them heavy _____

I found them painful _____

I found the pressure of the muffs on my ear too great _____

I didn't like the strange sound I heard _____

I had difficulty in identifying equipment sounds _____

I had difficulty in locating sounds _____

I thought they made my work more dangerous _____

They didn't fit properly _____

There were other reasons (Please write them here) _____

_____

_____

Wearing hearing protectors when working in loud noise can sometimes make it more difficult and sometimes make it easier to work. How did wearing protectors affect each of the following:

	Made it much easier	Made it a little easier	No difference	Made it a little more difficult	Made it much more difficult
Comfort	_____	_____	_____	_____	_____
Preventing hearing loss	_____	_____	_____	_____	_____
Conversation with fellow workers	_____	_____	_____	_____	_____
Ability to hear instructions	_____	_____	_____	_____	_____
Ability to hear warn warning shouts	_____	_____	_____	_____	_____
Ability to hear warning signals	_____	_____	_____	_____	_____

	Made it much easier	Made it a little easier	No difference	Made it a little more difficult	Made it much more difficult
Ability to hear important changes in equipment noise	_____	_____	_____	_____	_____
Ability to concentrate	_____	_____	_____	_____	_____
Other (Please explain)	_____	_____	_____	_____	_____

_____

_____

Do you think that it is a good idea to have these hearing protectors available?

Yes_____ No_____

Do you think that required use of hearing protectors in high-noise work areas is a good idea?

Yes_____ No_____

Should be up to the person_____

If no, could you tell us why you believe required use is not a good idea?

They would make my work more dangerous _____

I would not be able to talk to others _____

Other reasons (Please explain) _____

_____

_____

_____

Would you prefer to continue to use hearing protectors in your high-noise work?

Yes_____ No_____

Could you say why?

_____

_____

_____

_____

APPENDIX C/ WINTER SESSION DATA

WINTER SESSION, POST-QUESTIONNIARE

Post-questionnaire results concerning the number of times the operators plowed snow during the trial period reflected the mild weather conditions. Fourteen percent of the operators who returned post-questionnaires did not plow during the trial period and 57% plowed only once or twice. Overall, 90% of the operators plowed five times or less. None of the operators in the control group reported wearing hearing protectors while plowing snow. The experimental group operators were very co-operative with the program despite their limited opportunities. Seventy-six percent of the experimental operators wore protectors at least some of the time while plowing snow. Table C1 shows the frequency of use compared with the frequency of snow plowing.

Muffs were the most commonly used type of protector, although 24% of the experimental operators tried both muffs and plugs. Operators in the experimental group who did not always wear the protectors were asked for their reason(s). Table C2 shows how the reasons ranked based on the number of times an operator agreed with them. The operators could check as many reasons as they felt applied to them. The reasons most frequently checked were not believing that noise was a problem and fearing that important sounds would not be heard. Four out of the seven respondents making additional comments in the general comments section reported that wearing protectors interfered with their conversation. When asked if they would prefer to continue wearing protectors while plowing, only 26% of the operators who tried protectors during the trial period responded affirmatively. The reason most frequently given for not wishing to continue wearing protectors was that there was not enough noise to warrant their use, or just that they were not needed.

Finally, in the general comments concerning the problems of noise and/or the use of hearing protectors while plowing snow, six of the 14 experimental group operators who made comments stated that the decision to use protectors should be left to the individual. Four operators said they felt that hearing protectors were not good for snow plowing.

PRE-POST-QUESTIONNAIRE COMPARISONS

In both the pre- and post- questionnaires the operators were asked how noise affected their work. A comparison of the answers to the pre- and post- questionnaires would reveal if any major change in the work environment had taken place. The responses to the post-questionnaire showed a similar pattern to that of the pre-questionnaire. The majority of operators still felt that noise caused some difficulties in the areas of safety and communications.

The opinions of the control group operators concerning the availability of hearing protectors and their compulsory use while plowing snow did not change between the two questionnaires (none of the control operators used hearing protectors during the study period). The majority of the experimental group increased their support of the availability of muffs and plugs, but remained unchanged in saying that protector use should be an individual decision. Those experimental group operators who had an opportunity to plow snow and wear protectors increased their support for the availability of protectors from 80% to 92%. They showed a slight shift in their opinions about compulsory use with many of those who had favoured compulsory use in the pre-questionnaire softening their position and saying that the decision to use or not use protectors should be left up to the individual.

There was also a marked change in the reasons given by the operators who believed compulsory use was not a good idea. The operators were presented with three statements they could simply check off and were given the opportunity to make additional comments. Table C3 shows how the responses changed from the pre-questionnaire to the post-questionnaire. In all cases, there was a sharp increase in the number of negative opinions expressed by both the experimental and the control groups. The most striking is the increase in the number of experimental group operators who felt they would not be able to talk to others.

The pre-questionnaire responses of the experimental group operators to items dealing with the expected effect of hearing protectors on their work were compared to the post-questionnaire responses reporting the

actual effect of protectors on their work. In the pre-questionnaire the areas of most concern were hearing warnings and instructions. The post-questionnaire, however, showed that difficulties were less than had been anticipated. Operators who were of the opinion that hearing protectors would make various aspects of their work much more difficult often changed their opinion, reporting in the post-questionnaire that protectors made their work a little more difficult. For example, 50% of the operators who felt that protectors would make it much more difficult to hear warning shouts, reported that protectors had no effect or made hearing warning shouts only a little more difficult. The responses to items dealing with comfort, the ability to carry on conversation, and the ability to concentrate were very similar to those given in the pre-questionnaire.

A number of operator sub-groups were examined again. Since a low number of operators both used hearing protectors and had some snow plowing experience during the study, not all the desired comparisons could be made. Only four of experimental group operators who had reported that they had been accused of having a hearing problem completed the post-questionnaire. All four had experience plowing with protectors on; however, this is too small a group from which to draw conclusions. One set of subgroup comparisons that could be made was between operators who reported being around loud noise for part or most of each day vs. those who reported being around noise less often than every day. The subgroups had equal representation of operators who had plowed while wearing protectors during the study period. Operators who were less frequently exposed to noise did not show (in their responses to the pre-questionnaire) as much support as other operators for the availability and compulsory use of hearing protectors. However, in the post-questionnaire this subgroup showed increasing support for protector availability and compulsory use. Operators who were more frequently around noise reported they had less difficulty than expected in hearing warning signals and changes in important equipment sounds. Those less frequently around noise reported that the effect on their ability to concentrate was worse than they had previously expected.

INCIDENT REPORTS

No incident reports were completed during the one-month winter trial-use period.

GROUP DISCUSSION - GENERAL OBSERVATIONS

As with the summer trial-use session, an informal group discussion was held with each crew after the post-questionnaires were completed. Many of the experimental group operators felt that they had not really given the protectors a fair test because of the unusual weather conditions. Operators in both groups said that they really did not feel protectors were necessary inside a snowplow.

The majority of the experimental operators' complaints had to do with not being able to hear properly. One crew, in particular, complained that they had difficulty hearing their radio; although they all agreed that their radio system was not the best. They felt that this difficulty in hearing the radio was quite serious, given the type of highway they plow (six lanes with heavy traffic). Communication between plows, particularly with the lead plow of a group, is especially important to them since other traffic often passes on the right of the plows. Some of the operators said they could not hear the truck motor well enough to know when to shift, especially for downshifting. They also said that with protectors on, passing trucks could not be heard; whereas in the past they could hear other trucks passing. Passing cars, they said, could not be heard with or without protectors. The final complaint dealt with being able to hear conversation: The operators said that when they looked straight at the person who was talking they could hear properly, but it was much more difficult to hear when not facing that person. This, they felt was important, since the plow driver and wingman have little chance of facing each other while the plow is in motion.

WINTER SESSION CONCLUSIONS

The problems reported by the winter session operators dealt more with interference in communication than did the problems reported by the summer session operators. There were more complaints throughout the questionnaires about missing conversation. Comments from the group discussions identified problems of hearing both the radio and others in the truck. Although these comments were not always borne out by the results of the questionnaire, there was general agreement in the group discussions that these problems existed. One set of questionnaire responses that particularly reflected the operators' negative feelings, were the

reasons they gave to explain why they felt compulsory use was not a good idea. The sharp increase in the number of responses is some indication of the operators' feelings. The experimental group in particular, felt that they could not talk to one another.

There were some positive features to the questionnaire results. They suggest that protectors were found to be less of a problem than had been first expected. This is reflected in the increased support for the availability of protectors and the number of operators who switched from saying no to compulsory use to saying the decision should be left to the individual. Some specific situations such as hearing warnings and hearing changes in equipment noise were also found to be less difficult than had been expected.

Table C1/ A Comparison of the Frequency of Snow Plowing to the Frequency of Protector Use While Snow Plowing

How often was snow plowed?	How often were protectors worn while snow plowing?		
	Always	Some of the time	Never
Never	0%	0%	9.1%
1 - 2 times	6.1%	45.5%	15.2%
3 - 5 times	3%	18.2%	0%
6 - 10 times	3%	0%	0%

Table C2/ Why Operators Chose Not to Wear Hearing Protectors

Rank	N	Reason for not Wearing Hearing Protection*
1	17	I did not think the noise was hurting me.
2	15	I did not mind the noise.
4	12	The noise did not occur often enough to bother me.
4	12	I had difficulty in identifying equipment sounds.
4	12	I could not hear people talking to me.
6	11	I did not like the feel of the plugs in my ears.
7	8	I found them heavy.
9.5	7	I found them painful.
9.5	7	I found the pressure of the muffs on my ear too great.
9.5	7	I had difficulty in locating sounds.
9.5	7	I did not like the strange sound I heard.
13.5	6	I forgot to wear them.
13.5	6	I found them hot.
13.5	6	I had difficulty in locating sounds.
13.5	6	I thought they made may work more dangerous.
16.5	2	I did not know I was supposed to wear them.
16.5	2	They did not fit properly.

* Respondents could give more than one response.

Table C3/ Percentage of Operators Agreeing With Each Statement

Reasons Why Compulsory Use is Not a Good Idea	Control Group		Experimental Group	
	Pre-	Post-	Pre-	Post-
They would make my work more dangerous	42.6%	66.6%	36.5%	66.6%
I would not be able to to talk to others	38%	66.6%	34.6%	93%
Protectors are too uncom-table	17.6%	41%	9.6%	47%